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Environmental Mercury Contamination Around a Chlor-Alkali Plant

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The chlor-alkali industry is one of the most important emitters of mercury. This metal is effectively spread from chlor-alkali plants into the atmosphere and it has been reported that only a few percent of the mercury emissions are deposited locally the major part spreading over very large areas (Jernelöv & Wallin 1973, Lockeretz 1974, Wallin 1976, Högström et al. 1979). The purpose of this investigation was to study the spreading of mercury up to 100 km from a chlor-alkali plant using three different biological indicators.

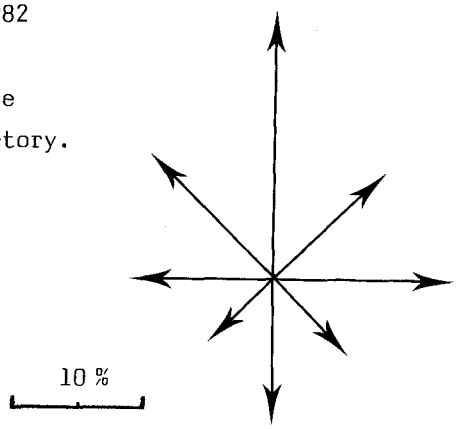
MATERIAL AND METHODS

The chlor-alkali plant is situated at the shore of Kokemäenjoki river in southwestern Finland. The mercury emission into the air was approximately 400 kg in 1981 and there are no other important mercury emitters in this area. Southerly winds prevail (Fig. 1). The mercury pollution of terrestrial and aquatic vegetation, lichens and fungi has been studied earlier (Lodenius 1980, 1981ab, Lodenius & Herranen 1981). A rural, unpolluted area 225 km east of the factory was used as a background area.

Mosses and lichens have been widely used as indicators of air-borne metal pollution. The moss-bag technique (Goodman et al. 1974, Mäkinen 1977) is especially suitable for monitoring dry deposition (Clough 1975), which is the main fallout process for mercury (Högström et al. 1979). However, the exact relationship between the actual deposition and the moss-bag value is not known.

The moss-bags were made of Sphagnum fuscum, S. riparium and S. balticum collected from unpolluted sites. The moss material was rinsed with deionized water, placed in polyamide nets and hung in trees at a height of 3-5 m (cf. Mäkinen 1977). Some of the moss material was rinsed with 0.5 % HNO_3 or 5% EDTA. However, the mercury contents of rinsed material did not differ from those obtained by untreated moss-bags and consequently rinsed and unrinsed data were combined. The mean dry weight of moss covering 1 dm^2 was determined to be 3.2 g. Moss-bags were placed along a transect 0-100 km north of the factory and along a 0-20 km transect

Fig. 1. The reverse wind rose for the study periods in 1982 and 1983 constructed on the basis of values from Tampere airport 60 km NE of the factory.



northeast of the factory at 34 sites for the period June - September 1982 (108 days). The experiment was repeated in February - May 1983 (92 days) at the northeast transect.

In September 1982 two-year old shoots of feather moss, Pleurozium schreberi, were collected from the two transects from 28 sites (no Pleurozium was found near the factory). Samples of the epiphytic lichen Hypogymnia physodes were collected both in September 1982 and February 1983.

RESULTS AND DISCUSSION

The mercury accumulation in moss-bags and the concentrations in mosses and lichens were significantly higher near the chlor-alkali plant than 20-100 km distant or in the background area (Table 1). The moss-bag and moss values were also higher 20-100 km from the plant than in the background area. The mean mercury content of Hypogymnia was slightly lower than in the background area, but higher than the mean background value for the whole of Finland (Lodenius 1981b). The variation in mercury values was greater at sites 20-100 km than in the background area obviously because of the greater heterogeneity in the sampling sites along this very long transect.

The moss-bag and lichen values did not differ significantly between the two study periods indicating that no substantial differences in the mercury deposition occur between summer and winter. Nor did

Table 1. Mercury accumulation in moss-bags, estimated mercury deposition and the mercury contents of mosses and lichens at different distances from the chlor-alkali plant compared to the background values.

		0 - 1 km	1 - 5 km	5 - 20 km	20 - 100 km	Background
Moss-bags	$\bar{x} \pm SD$	3800 ± 3600 (n=12)	790 ± 600 (15)	90 ± 56 (13)	48 ± 33 (9)	24 ± 84 (12)
(ng/g·a)	range	1500 - 16000	160 - 2600	36 - 250	0 - 84	-140 - 220
Mean deposition	($\mu g/m^2 \cdot a$)	1200	260	29	16	8
	(kg/a)*	3.8	19	25	230	
Pleurozium schreberi	$\bar{x} \pm SD$	-	590 ± 430 (8)	110 ± 30 (11)	170 ± 310 (9)	90 ± 13 (7)
(ng/g dry wt)	range		140 - 1400	70 - 170	40 - 140	70 - 110
Hypogymnia physodes	$\bar{x} \pm SD$	18000 ± 7600 (8)	2000 ± 1600 (9)	430 ± 170 (10)	290 ± 88 (9)	310 ± 55 (11)
(ng/g dry wt)	range	7900 - 29000	660 - 5700	300 - 730	130 - 450	200 - 420

*Total deposition originating from the plant (background deposition subtracted).

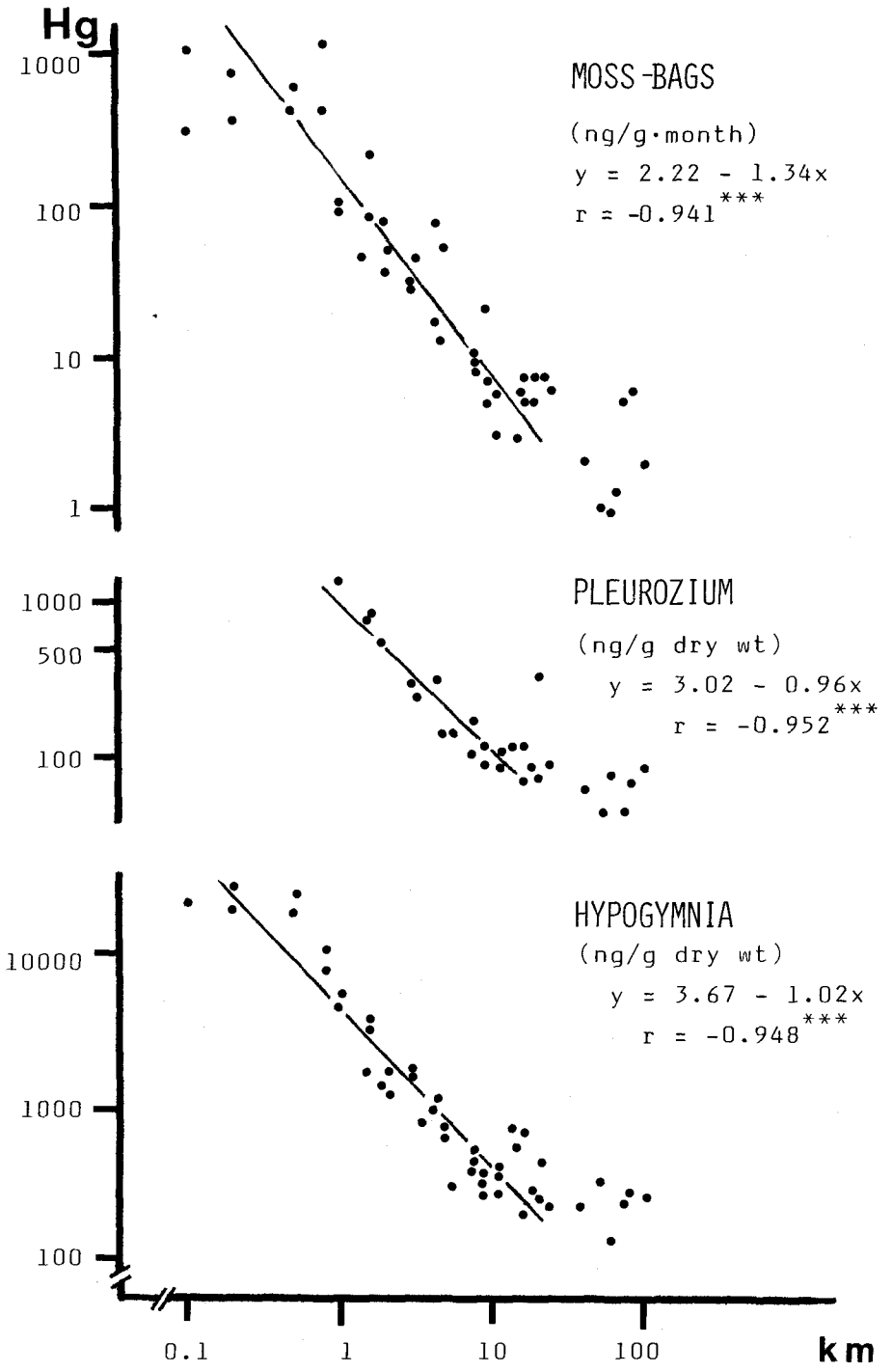


Fig. 2. The mercury accumulation in moss-bags and the mercury contents of Pleurozium schreberi and Hypogymnia physodes at different distances from the chlor-alkali plant. The correlations are calculated from data 0-20 km.

the values differ between the two transects and all results are included in Table 1 and Fig. 2.

The mercury values decreased exponentially with increasing distance from the plant as observed earlier (e.g. Wallin 1976, Lodenius & Herranen 1981). At distances of 0-20 km the negative correlations between the logarithmic values of distance and mercury contents were significant for all three indicators (Fig. 2). Consequently all these materials may successfully be used as bio-indicators of air-borne mercury pollution.

On the basis of the specific weight of the moss used for moss-bags a rough estimation of the mercury deposition around the chlor-alkali plant was made (Table 1). This implies that only 6% of the emission is deposited 0-5 km from the factory, which is in good agreement with the results from six Swedish chlor-alkali plants (Wallin 1976). Almost 60% of the emitted mercury is deposited at distances of 20-100 km. Bull et al. (1977) estimated from moss-bags a slightly higher annual mercury deposition near a chlor-alkali plant: 2300 µg Hg / m^2 near the factory (< 0.5 km) compared to 130 µg Hg / m^2 further distant (10-30 km).

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